

A preliminary study on in-stream large woody debris in broadleaved and Korean pine forest in Changbai Mountain, Northeast China

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Abstract: This study was conducted in Erdaobaihe River passing through the broadleaved and Korean pine forest located on the north slope of Changbai Mountain. In-stream large woody debris (LWD) in two segments of the river channel was investigated with base diameter, top diameter, length, and decay class. To study relationship between in-stream LWD and adjacent riparian forest, species of each log of LWD in segment 1 was identified, and the riparian forest was examined by setting a 32m×24 m quadrat consisting of twelve 8m×8m small quadrats. The results showed that, in segment 1, in-stream LWD loading was $1.733 \text{ m}^3/100\text{m}$ or $10.83 \text{ m}^3 \cdot \text{hm}^{-2}$, and in segment 2, it was $1.709 \text{ m}^3/100\text{m}$ or $21.36 \text{ m}^3 \cdot \text{hm}^{-2}$. In-stream LWD in decay class III and IV were accounted for a high proportion, which was different from that in the broadleaved and Korean pine forest, and the possible reason might be different decomposing velocities due to different decomposing conditions. Logs of LWD in stream and living trees in riparian forest declined as diameter increased, and it was in a reverse J-shaped distribution except logs of LWD in segment 1 in the first diameter class. Volumes of LWD in stream and living trees in riparian forest increased as diameter increased, and it was in a typical J-shaped distribution. Loading and species component of in-stream LWD were correlative to status of riparian forest to a certain extent, and there also existed difference. Comparing the correlation and difference was helpful to study on dynamic of the riparian forest.

Keywords: In-stream; large woody debris; Broadleaved and Korean pine forest; Changbai Mountain; Loading; Riparian zone

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Introduction

Large woody debris (LWD) is an important ecological component in terrestrial and aquatic ecosystems, and in forest ecosystems, it also has many crucial ecological functions such as habitat for organisms, a site for nitrogen fixation, energy flow, and nutrient cycling (Harmon *et al.* 1986; Hao *et al.* 1989). In temperate forest, LWD is the chief seedbed of forest regeneration (Dai *et al.* 2000). In China, the relative studies mainly focused on fallen wood and carried out in the temperate forests, especially broadleaved and Korean pine (*Pinus koraiensis*) forest, in Changbai Mountain from the early 1980s. Management of streams, lakes, and wetlands in forest ecosystems represents one of the most revolutionary changes in forestry in the latter half of the 20th century (Gregory 1997), and along with the continuous development of studies on stream ecosystems (Cummins 1974; Vannote *et al.* 1980; Minshall *et al.* 1985) and watershed ecology (Cai *et al.* 1997; Deng *et al.* 1998), the intercross and combination of terrestrial ecosystems and aquatic ecosystem research

become a new current in ecosystem studying. Although study on LWD is an important aspect in traditional forest ecology, increasingly more ecologists pay their attentions to in-stream LWD and are aware of the important effects of in-stream LWD in basic study and practical management (Deng *et al.* 2002).

While LWD in forest ecosystems, especially in riparian forests, turns into stream ecosystems because of natural power or human power, it is turned into in-stream LWD. In-stream LWD is one of the most important and intuitionistic input and disturbance of terrestrial ecosystems on stream ecosystems, and it is a major connection between terrestrial ecosystems and stream ecosystems (Deng *et al.* 2002). In-stream LWD also plays an important role in stabilization of stream ecosystem, aquatic biodiversity, and channel morphology and its change process (Triska *et al.* 1980; Lienkaemper *et al.* 1987; Nakamura *et al.* 1994; Hedman *et al.* 1996; Rikhari *et al.* 1998). Some studies showed that, although in-stream LWD loading varies greatly in different regions and stages (Harmon *et al.* 1986; Lienkaemper *et al.* 1987; Nakamura *et al.* 1994; Hedman *et al.* 1996), it is related to status of riparian forest closely.

In China, some studies have been carried out on fallen wood in forest ecosystems (Chen *et al.* 1992; Dai *et al.* 1994, 2000) and litter in aquatic ecosystems (Jiang *et al.* 2002), but it is not sufficient owing to lack of relative studies on in-stream LWD directly. In this study, in-stream LWD were investigated in the broadleaved and Korean pine forest on the north slope of Changbai Mountain, and LWD loading and its distribution in different decay and diameter

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size classes were mainly studied. Furthermore, the relationship between in-stream LWD and adjacent riparian forest was also discussed.

Study sites and methods

This study was conducted in Erdaobaihe River passing through the broadleaved and Korean pine forest and located on the north slope of Changbai Mountain. Erdaobaihe River originates from Tianchi (Sky Lake), a volcanic lake, on the top of Changbai Mountain, and it is the upriver source of Songhua River. From the peak to the piedmont, Erdaobaihe River passes through all the different vegetation zones on the north slope. Broadleaved and Korean pine forest, which is distributed below 1 100 m above sea level, is one of the vegetation zones in the mountain. The dominant tree species in the original broadleaved and Korean pine forest are Korean pine, *Tilia amurensis*, *T. mandshurica*, *Quercus mongolica*, *Fraxinus mandshurica*, and *Acer mono* (Dai *et al.* 2000). There are also *Larix olgensis*, *Abies nephrolepis*, *Ulmus japonica*, *U. laciniata*, *Populus ussuriensis*, *Populus davidiana*, *Betula platyphylla*, and *B. costata* with different quantity in the existent forest because of different disturbances.

Two segments of the river channel were selected to investigate in-stream LWD. Segment 1 was located from 128°05'39"E, 42°20'55"N to 128°05'23"E, 42°19'52"N at an elevation of 800–900 m, and the length was about 4 500 m. Segment 2 was located from 128°07'07"E, 42°10'41"N to 128°05'57"E, 42°13'35"N at an elevation of 950–1100 m, and the length was about 12 000 m. Each log of LWD >1 m long and >2.5 cm diameter was recorded with base diameter, top diameter, length, and decay class. In this study, the five decay classes were utilized (Rikhari *et al.* 1998; Deng

et al. 2002). Every certain distance, GPS were used to determine location, and width of river and velocity of water flow were also measured. To study relationship between in-stream LWD and adjacent riparian forest, species of each log of LWD in segment 1 was identified, and the riparian forest was examined by setting a 32 m×24 m quadrat consisting of twelve 8 m×8 m small quadrats at an elevation of 850 m. In each small quadrat, each tree >1 m long and >2.5 cm diameter was recorded with species, height, and diameter. All the field investigations were carried out in summer of 2001.

The volume of each log of LWD was calculated by the following formula:

$$V = \frac{\pi h}{12} (r_1^2 + r_1 r_2 + r_2^2)$$

where V is volume, r_1 and r_2 are base diameter and top diameter, respectively, and h is length.

Results and discussion

LWD loading and its distribution in different decay classes

425 and 1 670 logs of LWD were found in segment 1 and segment 2 of the investigated river channel, and their total volume was 77.98 m³ and 205.10 m³, respectively (Table 1). The average river width of segment 1 and segment 2 was about 16 m and 8 m. In segment 1, in-stream LWD loading was 1.733 m³/100 m or 10.83 m³·hm⁻², and in segment 2, it was 1.709 m³/100 m or 21.36 m³·hm⁻². It showed that LWD loading per river length was a good index to scale in-stream LWD loading.

Table 1. Total number and volume of in-stream LWD in two segments in different decay classes

Decay classes	Segment 1 (4 500 m long)				Segment 2 (12 000 m long)			
	No.	Volume	Mean volume	Mean length	No.	Volume	Mean volume	Mean length
	/log	/m ³	/m ³	/m	/log	/m ³	/m ³	/m
I	24	4.62	0.19	10.1	51	5.99	0.12	8.1
II	61	9.14	0.15	7.6	114	24.00	0.21	8.1
III	178	34.18	0.19	6.7	512	63.12	0.12	4.9
IV	153	29.07	0.19	5.5	961	107.13	0.11	3.8
V	9	0.98	0.11	3.8	32	4.85	0.15	3.9
Sum	425	77.98	0.18	6.5	1670	205.10	0.12	4.6

In segment 1, LWD in decay class III and IV were accounted for 78% of total logs and 81% of total volumes, and in segment 2, the corresponding values were 88% and 83%, respectively. It was different from that in forest. According to other studies (Dai *et al.* 2000), LWD in decay class II and III are accounted for 75% of total volumes in the broadleaved and Korean pine forest. The possible reason was different decomposing velocities due to different decomposing conditions. Logs and volumes of LWD in decay class V were both the least. In general, mean length

and mean volume of coarse woody debris (CWD) decrease in the classes of more advanced decay (Nakamura *et al.* 1994). In our study, mean length of LWD decreased basically while decay class increasing, but change of mean volume had no obvious orderliness. Mean volume per log in different decay classes varied in a narrow range. It implies that LWD in stream farmed in different stage has no obvious difference in mean volume.

Distribution of LWD in different diameter classes

Distribution of logs and volumes of LWD in two segments and living trees in riparian forest in different diameter classes was showed in Fig.1, and the 6 diameter classes were 2.5-7.5 cm, 7.6-15.0 cm, 15.1-22.5 cm, 22.6-30.0 cm, 30.1-37.5 cm, and >37.5 cm. Logs and volumes of LWD in different diameter classes were different (Fig.1).

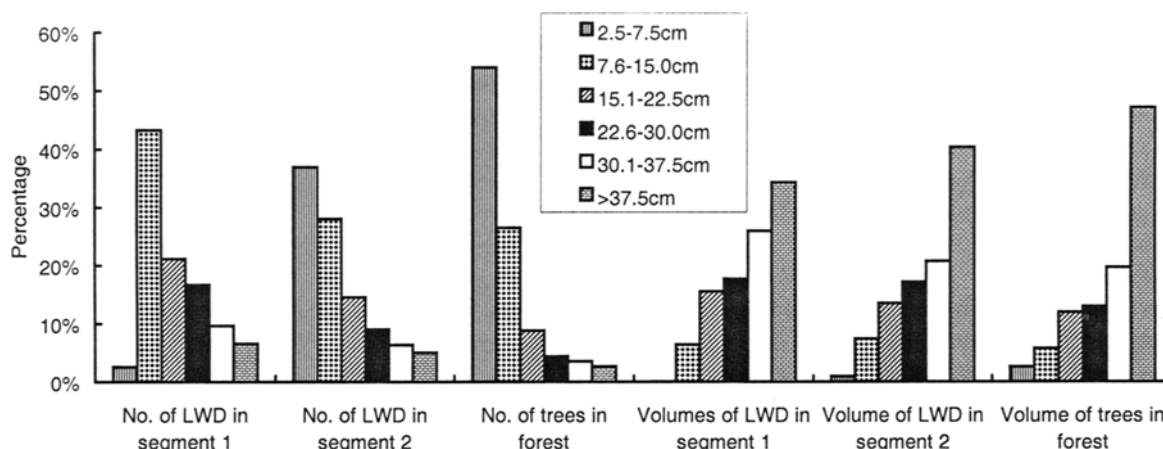


Fig.1 Distribution of logs and volumes of LWD and living trees in different diameter classes

Logs and volumes of LWD in stream and living tree in adjacent riparian forest in different tree species

In segment 1, 17 tree species of LWD were recorded, and logs and volumes of in-stream LWD of different tree species were shown in Table 2. Among 17 tree species, nine of them had logs over 10 and volume over 1 m³, and accounted for 96% of total logs and 98% of total volumes, respectively. Among the 9 species, number of broadleaved tree species was 6, and accounted for 45% of total logs and 40% of total volumes. Among all the 17 species, number of coniferous tree species was 4, but they accounted for 50% of total logs and 58% of total volumes. All the results were correlative to status of riparian forest (Table 3) to a certain extent. In the investigated riparian forest, volumes of coniferous tree species was due to Korean pine mainly and less than those of broadleaved tree species obviously, which was different from results on in-stream LWD. In addition, stumpage volume of the investigated riparian forest was 239.96 m³·hm⁻². In general, volume of broadleaved and Korean pine forest is 350-400 m³·hm⁻², and volume of LWD in the forest aged 350 years is 40-50 m³·hm⁻² (Dai *et al.* 2000).

Contrasting Table 2 with Table 3, LWD of *Larix olgensis* and *Populus spp.* had a great proportion of volume, but in the investigated riparian forest, it was found only as few seedlings. Two possible reasons could be accepted. Firstly, the investigated quadrat was located at elevation of 850 m with a length of 32 m along the river. The status of the quadrat was not able to reflect the entire distribution status of all the LWD in the 4 500m long river way. Secondly, dynamic of riparian forest and different propensities of tree species could cause different regeneration for a specific

Logs of LWD in stream and living trees in riparian forest declined as diameter increased, and it was in a reverse J-shaped distribution except logs of LWD in segment 1 in the first diameter class. Volumes of LWD in stream and living trees in riparian forest increased as diameter increased, and it was in a typical J-shaped distribution.

tree species. Thus, large stumpage of specific tree species such as *Larix olgensis* and *Populus spp.* would disappear in a certain riparian segment and turn into in-stream LWD, and both the two species were considered as pioneer species. To confirm the second reason, a farther study should be carried out. Mean volume per log of living tree and in-stream LWD of different species varied both in a wider range, but between them, there was not obvious relevancy.

Table 2. Logs and volumes of in-stream LWD of different tree species in segment 1

Tree species	Logs	Volume /m ³	Mean volume /m ³
<i>Larix olgensis</i>	60	20.76	0.35
<i>Abies nephrolepis</i>	144	16.67	0.12
<i>Populus spp.</i>	110	15.13	0.14
<i>Pinus koraiensis</i>	10	7.46	0.75
<i>Quercus mongolica</i>	14	7.16	0.51
<i>Tilia spp.</i>	10	3.17	0.32
<i>Fraxinus mandshurica</i>	10	2.22	0.22
<i>Maackia amurensis</i>	31	2.19	0.07
<i>Betula spp.</i>	18	1.38	0.08
<i>Acer mono</i>	6	0.79	0.13
<i>Ulmus spp.</i>	5	0.53	0.11
<i>Rhamnus davurica</i>	1	0.40	0.40
<i>Phellodendron amurense</i>	1	0.03	0.03
<i>Picea jezoensis</i> var. <i>komarovii</i>	1	0.03	0.03
<i>Syringa spp.</i>	2	0.02	0.01
<i>Sorbus pohuashanensis</i>	1	0.01	0.01
<i>Cerasus maximowiczii</i>	1	0.01	0.01
Sum	425	77.98	0.18

Table 3. Logs and volumes of different tree species in the investigated riparian forest (32 m×24 m)

Tree species	Logs	Volume /m ³	Mean volume /m ³
<i>Q. mongolica</i>	5	4.08	0.82
<i>P. koraiensis</i>	1	3.84	3.84
<i>Betula spp.</i>	11	3.80	0.35
<i>Tilia spp.</i>	3	2.20	0.73
<i>F. mandshurica</i>	2	1.22	0.61
<i>Acer spp.</i>	87	1.02	0.01
<i>Phellodendron amurense</i>	3	0.80	0.27
<i>Ulmus spp.</i>	8	0.75	0.09
<i>A. nephrolepis</i>	18	0.43	0.02
<i>Syringa spp.</i>	29	0.24	0.01
<i>Sorbus pohuashanensis</i>	1	0.04	0.04
Sum	168	18.43	0.11

Logs and volumes of LWD of different tree species in different decay classes

Table 4 showed the distribution of LWD of different tree species in different decay classes. Only 7 species were listed because LWD of other species distributed in fewer decay classes. Logs and volumes of LWD in decay class III and IV of most species were accounted for a high proportion, but LWD of *Betula spp.* in decay class II and III were accounted for a high proportion. Both of *Larix olgensis* and *Populus spp.* had a great proportion of LWD volume, but in the investigated riparian forest, they disappeared increasingly. There was no LWD of *Larix olgensis* in decay class I, which implied that *Larix olgensis* disappeared more early than *Populus spp.*. Logs and volumes of *Quercus mongolica* in the foregoing four decay classes differed slightly, and the species was dominant in the riparian forest (Table 3). The results implied that LWD of *Quercus mongolica* with certain quantity were formed in the near foretime.

Table 4. Logs and volumes of LWD of different tree species in different decay classes

Tree species		Decay classes				
		I	II	III	IV	V
<i>Larix olgensis</i>	Number	0	6	27	26	1
	Volume /m ³	0	1.43	9.39	9.91	0.04
<i>A. nephrolepis</i>	Number	6	23	43	69	3
	Volume /m ³	0.56	2.21	5.83	7.67	0.42
<i>Populus spp.</i>	Number	4	14	63	28	1
	Volume /m ³	1.83	1.38	8.42	3.40	0.10
<i>P. koraiensis</i>	Number	1	1	4	3	1
	Volume /m ³	0.01	0.43	4.16	2.69	0.17
<i>Q. mongolica</i>	Number	3	3	2	5	1
	Volume /m ³	1.29	1.02	1.89	2.92	0.06
<i>Maackia amurensis</i>	Number	1	4	14	10	2
	Volume /m ³	0.01	0.24	0.99	0.76	0.20
<i>Betula spp.</i>	Number	3	3	9	3	0
	Volume /m ³	0.29	0.45	0.50	0.14	0

In this study, LWD loading and its distribution in different decay classes, diameter classes, and different species were analyzed and discussed preliminarily, and some anticipative results were acquired. We also obtained some results differing from others'. In conclusion, studies on in-stream LWD will be helpful to deepen studying LWD and forest ecosystem, and the management based on the studies will be useful to contain stability of river ecosystem and protect biodiversity.

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